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Trade openness and investment in North Africa

A CGE application to deep and comprehensive free trade areas (DCFTAs)
between the EU and respectively Egypt, Morocco and Tunisia

Authors in alphabetical order

Boulanger Pierre [†]
Kavallari Aikaterini [‡]
Rau Marie-Luise [‡]
Rutten Martine [‡]

Abstract:
The aim of this paper is to provide an impact analysis of deep and comprehensive free trade areas (DCFTAs) between the European Union (EU) and most of the North-African (NAF) countries – namely Egypt, Morocco and Tunisia. Scenarios are modelled with MAGNET, a general equilibrium model, and focus on trade liberalisation including non-tariff measures (NTMs) on the one hand, increases in foreign direct investments (FDIs) and capital flows on the other. They assume either broad productivity gains in all sectors of NAF countries, or targeted productivity gains in the agricultural sector aiming to reduce losses (waste) in NAF countries' agricultural production, post-harvest handling and storage. Results suggest that economic growth is stimulated mostly by widespread productivity gains, and boosted by trade liberalisation. Positive impacts on economic growth could thus be intensified by combining pro-investment policies with comprehensive trade liberalisation, especially the removal of NTMs. The effects on jobs and food security remain ambiguous.

[†] European Commission JRC-IPTS
[‡] Agricultural Economics Research Institute (LEI), part of Wageningen University and Research

1. Introduction

The south-Mediterranean region experiences a political turmoil. Most of the North-African (NAF) countries are engaged in a process of democratic and economic reforms. In 2011 the EU Foreign Affairs Council authorised the opening of new trade negotiations with Egypt, Morocco, Tunisia and Jordan. This decision provides the European Commission with a mandate to negotiate deep and comprehensive free trade areas (DCFTAs). Compared to current trade relationships between the European Union (EU) and these countries, the DCFTAs will go beyond removing tariffs to cover a range of regulatory issues such as technical barriers (TBT), sanitary and phytosanitary (SPS) measures, investment protection, public procurement, competition policy, etc. It is thus assumed that DCFTAs will increase foreign direct investments (FDIs) and capital flows in partner countries, leading to productivity gains.

This paper presents a general equilibrium modelling approach to simulate DCFTAs between the EU and most of the NAF countries – namely Egypt, Morocco and Tunisia – in the light of the Arab Spring developments, thereby capturing the macro perspective of economic integration. In the analysis, we apply the MAGNET (Modular Applied General Equilibrium Tool) model that builds upon the well know GTAP (Global Trade Analysis Project) model. We concentrate on the agri-food sector and report on the regional effects in NAF countries, with special attention to the impacts on growth, jobs and food security. We consider the following scenarios as MAGNET simulations:

(i) Trade liberalisation scenario which shows the potential impacts of agri-food trade liberalisation between NAF and EU countries in the context of DCFTAs negotiations. This scenario pays special attention in removing non-tariff measures (NTMs) – such as SPS measures or TBT – which jeopardize productivity gains;

(ii) Broad public and private investment scenario which captures the effects of an increase in total factor productivity. This scenario sheds some light on the effects of FDIs and capital flow increase in NAF countries;

(iii) Targeting food waste scenario which focuses in the improvement of food chain efficiency. This scenario assumes an increase of total factor productivity aiming to reduce losses (waste) in NAF countries' agricultural production, post-harvest handling and storage.

The remainder of this paper is set out as fellows. Section two presents the MAGNET model developed by LEI, as well as data and aggregation used in this study. In section three, the scenarios are outlined and discussed. Section four is dedicated to the presentation and interpretation of the results, and section five concludes.

2. The MAGNET (Modular Applied General Equilibrium Tool) model

2.1 Description of the MAGNET model

The MAGNET (Modular Applied General Equilibrium Tool) model is a general equilibrium model that builds upon the core of the GTAP (Global Trade Analysis Project) model. The main extension of the MAGNET model are a more sophisticated production and consumption structure, segmented factor markets as well as endogenous land supply. This extension makes the MAGNET model suitable for carrying out trade liberalisation analyses with a focus on agriculture. The GTAP core of MAGNET is described in detail in Appendix A.1.

In the general equilibrium modelling framework, demand for and supply of commodities and endowments meet in markets, which are perfectly competitive and which clear via price adjustments. Natural resources and land are assumed to adjust sluggishly between sectors. Based on respective assumptions regarding labour, land and capital markets, the MAGNET modelling features extend the standard GTAP model as follows: more sophisticated production structure (to account for inherent differences in the degree of substitutability between land and non-land factors), a consumption structure that reflects changes in taste over time (towards meats, dairy, fish, fruit and vegetables, and away from staple foods), segmented (agri-non, agri) factor markets and endogenous land supply (whereby land supplied to agriculture may respond to changes in the land rental rate). Each of these extensions is discussed in more detail in Appendix A.2.

2.2 Data and aggregation

The MAGNET model is calibrated using the GTAP v8 with base year 2007. For our modelling, the 129 countries and/or regions and 57 sectors available in the GTAP database are respectively aggregated to 21 regions and 29 sectors (Table 1, first column). The three countries of interest abbreviated as NAF, namely Egypt (egy), Morocco (mor) and Tunisia (tun) are separated from the rest of the Middle East and North Africa (MENA) region. Turkey as a major trade actor in the Mediterranean area is treated separately. The EU27 is divided into southern countries of Spain, France, Greece, Italy and Portugal, as they are more closely integrated with NAF, as well as the small island states of Cyprus and Malta. The other EU Member States are aggregated as the rest of the EU27. The European Free Trade Area (EFTA) and Croatia as an accessing country to the EU are distinguished from the rest of Europe. The remaining regions are summarised as geographical regional categories.

Given the focus of this paper on agri-food products, primary (agricultural) and (processed) food products that are important in trade between Egypt, Morocco, Tunisia, and the EU27 are most disaggregated for the model simulations (Table 1, second column). Other food products are included in an aggregate of food, beverages and tobacco. For products other than agri-food products, we distinguish forestry and fishing as related primary sectors, textiles and clothing, an important export product of NAF countries, natural resource sectors (coal, oil, gas and derived petroleum and coal products), other manufacturing and services. Note that we differentiate between trade and transport as one specific category of services and other services.

With regard to factors of production, we retain the standard GTAP categories of five production factors, which include skilled and unskilled labour, capital, land and natural resources (Table 1, last column).

Table 1 Region, sector and factor aggregation

Countries, regions		Sectors		Factors of production
egy	Egypt	pdr	Paddy rice	Land
mor	Morocco	wht	Wheat	Unskilled labour
tun	Tunisia	gro	Cereal grains nec	Skilled labour
tur	Turkey	v_f	Fruit and vegetables	Capital
MENA	Rest of Middle East and North Africa	osd	Oil seeds	Natural resources
esp	Spain	c_b	Sugar cane, sugar beet	
fra	France	pfb	Plant-based fibers	
grc	Greece	ocr	Crops nec	
ita	Italy	ctl	Cattle,sheep, goats, horses	
prt	Portugal	oap	Animal products nec	
EUIS	Cyprus and Malta	rmk	Raw milk	
RE27	Rest of EU27	wol	Wool, silk-worm cocoons	
EFTA	European Free Trade Association	frs	Forestry	
cro	Croatia	fsh	Fishing	
ROE	Rest of Europe	coa	Coal	
US	United States of America	oil	Crude oil	
NAM	Rest of North America	gas	Gas	
CSA	Central and South America	cmt	Meat: cattle, sheep, goats, horse	
OCE	Australia, New Zealand and Rest of Oceania	omt	Meat products nec	
ASIA	Asia	vof	Vegetable oils and fats	
SSA	Sub Saharan Africa	mil	Dairy products	
		pcr	Processed rice	
		sgr	Sugar	
		FBT	Food, bev & tobac prod nec	
		TCL	Textiles & clothing	
		p_c	Petroleum, coal products	
		MNF	Other manufacturing	
		TRA	Trade & transport (services)	
		SVC	Other services	

3. Scenarios

We conduct three scenarios in the MAGNET simulation analysis. The first scenario, called hereafter the Trade Liberalisation (TL) scenario, examines the consequences of reciprocal tariff and non-tariff liberalisation between the EU and NAF countries, and between NAF countries. The second scenario reflects increases in *broad* public and private investment (BI) which are traduced in productivity gains in the whole NAC economies. These investments are part of a growth agenda promoted by EU programmes and within the foreseen DCFTAs. The third scenario assumes productivity gains through improvements of food chain efficiency. It focused on *targeted* public and private investments (TI) aiming to reduce losses (waste) in NACs' agricultural production, post-harvest handling and storage.

The aforementioned scenarios are compared to the baseline, which constitutes the Business-as-Usual (BaU) scenario.[1] In MAGNET, the BaU scenario is run for the period 2007-12 to project the model towards the current year, and then up to 2020. It is generated using information on the expected growth path of the economy (GDP) and endowments (capital, labour, land and natural resources) over time for all countries and/or regions in the world, and the productivity of these endowments, most notably that of land, i.e. yields.[2] We do not model any change in European and NAF countries agricultural policies.

[1] For sake of simplicity BaU outcomes are not reported in the paper but are available upon request to the authors.
[2] This information is used to derive the implied technological change by region, which is subsequently fixed so as to endogenously generate the targeted GDP.

3.1 Trade liberalisation scenario (TL)

This scenario quantifies the impacts of preferred market access that could be part of DCFTAs between the EU and the NAF countries. In detail, the TL scenario assumes reciprocal elimination of import tariffs for trade flows between the EU and the NAF countries as well as between the NAF countries (intra-NAF trade). In addition to tariff liberalisation, NTMs that hamper trade between the countries involved in the DCFTA are usually addressed as a main provision in DCFTAs. In the TL scenario, we simulate a reduction of NTMs by reducing so-called "iceberg costs". The TL scenario is simulated in two steps, S1 and S2 as presented in Table 22. In the following, we provide the details on the tariff elimination and the reduction of NTMs, including information about the modelling approach adopted.

Table 2 Overview of trade liberalisation (TL) scenario

Scenario	Assumptions
S1: Tariff elimination	Elimination of the tariffs presented in Table 3 between countries as follows: • EU27 – NAF • NAF – EU27 • intra-NAF trade
S2: Tariff elimination + reduction of NTMs	Tariff elimination as in S1 + reduction of NTMs, shown in Table 4

Tariff elimination

Table 3 shows the 2007 tariff schedule of the relevant import flows as included in the version 8 of the GTAP database (GTAPv8). The tariff schedule is presented as ad valorem equivalent rates in percentages. The EU imposes the highest ad valorem tariff rates on imports of vegetable oil and fats (abbreviated by vof) as well as and on sugar (abbreviated by sgr) imports (Table 1, second column). Regarding vegetable oil, EU tariffs are highest for Tunisia (42.6%); EU tariffs on sugar are the highest for Morocco (42.8%).[3] It should be noted that olive oil is part of the product category "vegetable oils and fat", and the high level of EU protection of olive oil (including tariff rate quotas) is reflected in the high tariff rate (Commission Regulation 1918/2006).

The NAF countries impose tariffs on imports from the EU of meat products, fish and processed food and beverages. By far, Egypt imposes the most restrictive tariff rate on EU products of food and beverages (254.2%). Morocco mainly protects paddy rice (93.5%) and beef meat (94.2%), while Tunisia imposes high tariffs on wheat (67.7%) and coarse grains (71.2%), fruit and vegetables (73.1%), live cattle animals (78.5%), dairy products (61.8%) and beef meat (64.6%). Overall, tariffs for trade across the NAF countries (intra-NAF trade) are very low. This could be because these countries may not have an interest for tariff protection of trade amongst each other. Note that Egypt, Morocco and Tunisia are part of further preferential agreements, for example the Agadir Agreement of 2004. Overall, trade flows amongst these countries are limited (Eurostat, 2009).

[3] The numbers in brackets refer to the ad valorem equivalent tariff rates, as presented in Table 3.

Table 3 Ad valorem equivalent import tariffs (%) by source and destination country: Egypt, Morocco, Tunisia, and EU27

	EU27 tariffs on imports from			Egyptian tariffs on imports from			Moroccan tariffs on imports from			Tunisian tariffs on imports from		
	EGY	**MOR**	**TUN**	**EU27**	**MOR**	**TUN**	**EU27**	**EGY**	**TUN**	**EU27**	**EGY**	**MOR**
pdr	9.0	0.0	0.0	0.0	0.0	0.0	93.5	0.0	0.0	31.8	0.0	0.0
wht	0.0	0.0	0.0	2.0	0.0	0.0	37.0	0.0	0.0	67.7	0.0	0.0
gro	3.6	0.0	0.2	2.1	0.0	0.0	9.0	0.0	0.0	71.2	0.0	0.0
c_b	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
osd	0.0	0.0	0.0	1.9	0.0	0.0	48.1	0.0	0.0	27.6	0.0	0.0
v_f	6.3	9.5	4.6	0.8	0.0	0.0	27.1	5.1	0.0	73.1	0.0	0.0
ocr	0.4	0.4	0.7	13.3	0.0	0.0	5.6	0.8	0.9	28.5	0.0	0.0
rmk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
oap	0.1	0.5	0.0	2.9	0.0	0.0	2.4	0.0	0.0	53.3	0.0	0.0
ctl	2.3	1.5	1.6	3.3	0.0	0.0	4.1	0.0	0.0	78.5	0.0	0.0
frs	0.0	0.5	0.4	1.2	0.0	0.0	3.6	0.0	0.0	5.1	0.0	0.0
vof	22.0	14.9	42.6	10.6	0.0	0.0	18.2	0.1	0.3	24.8	0.0	0.0
FBT	6.6	2.0	2.1	254.2	0.0	0.0	23.0	0.6	10.5	34.7	0.0	0.0
sgr	17.6	42.8	0.6	7.5	0.0	0.0	44.9	0.0	0.0	17.8	0.0	0.0
mil	2.3	4.5	4.6	7.5	0.0	0.0	37.8	0.2	0.0	61.8	0.0	0.0
pfb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
wol	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
CMT	3.6	1.4	0.0	10.2	0.0	0.0	94.2	0.0	0.0	64.6	0.0	0.0
fsh	5.6	0.0	0.0	2.9	0.0	0.0	48.6	0.0	0.0	42.7	0.0	0.0
pcr	27.1	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	31.2	0.0	0.0
TCL	0.0	0.0	0.0	21.0	0.0	0.0	8.4	1.3	0.0	7.1	0.0	0.0
p_c	0.0	0.0	0.0	5.1	0.0	0.0	10.1	11.9	0.0	1.0	0.0	0.0
MNF	0.0	0.0	0.0	7.9	0.0	0.0	6.8	0.3	0.2	3.9	0.0	0.0
SVC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: see Table 1 for sector full names.

Source: GTAPv8 database.

Looking at manufactures (abbreviated by MNF), the EU does not impose tariffs on manufacturing products from NAF countries. On the other hand, NAF countries however have tariffs on manufacturing products from the EU27. All three NAF countries under review impose tariffs on EU textiles and clothes, petroleum and coal products and other manufactured products. With regard to intra-NAF trade, only Morocco and Tunisia respectively impose tariffs but the tariff rates are comparably small (Table 3, third and fourth columns). In conclusion, tariff barriers amongst the NAF countries can be considered as being rather minor.

Reduction of non-tariff measures (NTMs)

Given that NTMs cause significant barriers to trade, we consider the abolishment of such measures in the simulation of trade liberalisation, which ultimately reflects the situation of free trade between the countries under review. There are many different types of NTMs; for an up-date classification of measures see UNCTAD (2007).Tariff rate quotas (TRQs) are a relevant category of NTMs related to traditional trade policy measures. For the NAF countries, TRQs are particularly relevant for access of fruit and vegetables but also processed products thereof, such as olive oil for example, to the EU

market. Another important category of NTMs are standards and other requirements that exporters have to comply with to supply foreign markets. It is usually distinguished between sanitary and phytosanitary (SPS) measures, which are implemented for human, animal and plant health reasons, and measures of technical barriers to trade (TBT), which specify technical and information requirements. In general, such requirements are behind the border measures and cause trade costs in terms of compliance costs. For NAF countries, issues of complying with SPS and technical requirement have been identified by ITC surveys in the respective countries (ITC, 2012a and b). Exports of agri-food products seem to be particularly affected, with more than half of the NTM issues reported being linked to compliance with SPS and technical requirements. In summary, product-specific tolerance limits for residues (Maximum residue levels, MRLs), hygiene measures, labelling and packaging have caused problems for exporting to the EU market. Exporters in NAF countries consider the EU conformity assessment, involving testing and certification that products meet the requirements as demanded, as being particularly burdensome.

In the simulation, we depict the removal of such trade barriers by the standard "iceberg cost" approach.[4] "Iceberg costs" are considered real trade costs that use up resources of exporters. As such, "iceberg costs" melt away a fraction of the export value on the way from the exporting to the importing country, causing efficiency losses in the exporting country. Reducing "iceberg cost" implies lowering real trade costs, which in turn boosts the efficiency of producing export products. Hence, exports increase and export prices decrease. In essences, the "iceberg cost" approach depicts the reduction of NTMs in terms of a positive technological change for producing for the world market.

For the simulation, we use the estimates of value equivalents by Kee et al (2009). In a gravity estimation, they quantified the effects of NTMs, which are subsequently transferred into price effects expressed in terms of average value equivalents. Table 4 presents the equivalent estimates of NTMs that the countries under review impose on agri-food products and manufacturing products, respectively. The estimates are based on imports and thus reflect the barrier that the respective countries impose on imports from all partner countries. Since the focus of our analysis is on Egypt, Morocco, Tunisia, and the EU27 as one entity, the estimates by Kee et al. (2009) seem to overestimate the NTM barriers. Note that the estimates for the EU27 only capture barriers between the EU Member States and third countries outside the EU (extra-EU trade). Another limitation of the estimates is the lack of detailed information about barriers for specific products.

Table 4 Ad valorem tariff equivalents of NTMs (%) by imposing country

Importing country	Year of estimation	Agri-food products	Manufacturing products
Egypt	2009	14	8
Morocco	2009	39	4
Tunisia	2006	45	10
EU27 (extra-EU trade)	2009	27	2

Source: Kee et al (2009).

3.2 Productivity gain scenarios: broad investments (BI) and targeted investments (TI)

One objective of DCFTAs is to boost overall economic growth which can be achieved *inter alia* by increased FDIs and capital flows in the partner countries. Literature on the link between foreign direct

[4] For a stylist application of the "iceberg" costs approach, see Fugazza and Maur (2008).

investment and total factor productivity (TFP) is extensive. Results are inconclusive as effects crucially depend on the type of investment and specificities of the partner countries. Based on the findings of Cecchini and Lai-Tong (2008), and given this background information, the scenario on the promotion of broad public and private investment in NAF countries (BI scenario) assumes that that FDI (within the DCFTAs) in Mediterranean countries would lead to a TFP increase of approximately 0.15%. In a period of ten years, this amounts to roughly 1.5% on average. We incorporate this higher growth path over the second period (1.5% over 2012-2020) assuming that technological progress is impacting sectors and factors in the same way as in the BaU.

In agriculture, the high losses in agricultural production and post-harvest handling and storage in North African countries, but also elsewhere in the developing world, are a big cause for concern in view of the importance of safeguarding food security.

Given this background, we consider a scenario that addresses food waste through targeted investments that simulate TFP increases in the agricultural sector. The TI scenario targets the losses (food waste) in the stages of agricultural production and post-harvest handling and storage in NAF countries. Due to the boost in agricultural productivity more output will be produced resulting in a higher production, but also less input will be used in producing these outputs. The model determines the optimal input-output mix, whereby losses on both input and output side will be reduced. The productivity increases have been derived from FAO data on estimated/assumed waste percentages for commodity groups in the steps of agricultural production and post-harvest handling and storage of the food supply chain for North Africa, West and Central Asia (FAO, 2011). The resulting productivity shocks are shown in Table 5.[5] Note that we incorporate this higher agricultural growth path over the second period (2012-2020), in addition to the technological progress as assumed in the baseline.

Table 5 TFP growth in agricultural sectors of NAF countries, 2012-2020 (TI scenario)

Sector	TFP growth	Sector	TFP growth
Paddy rice	14%	Other crops	30%
Wheat	14%	Cattle	7%
Other grains	14%	Other animal products	7%
Fruit and vegetables	30%	Fishing	12%
Oil seeds	24%	Raw milk	10%
Sugar cane, sugar beet	16%		

Source: derived from FAO (2011).

4. Results of MAGNET simulation

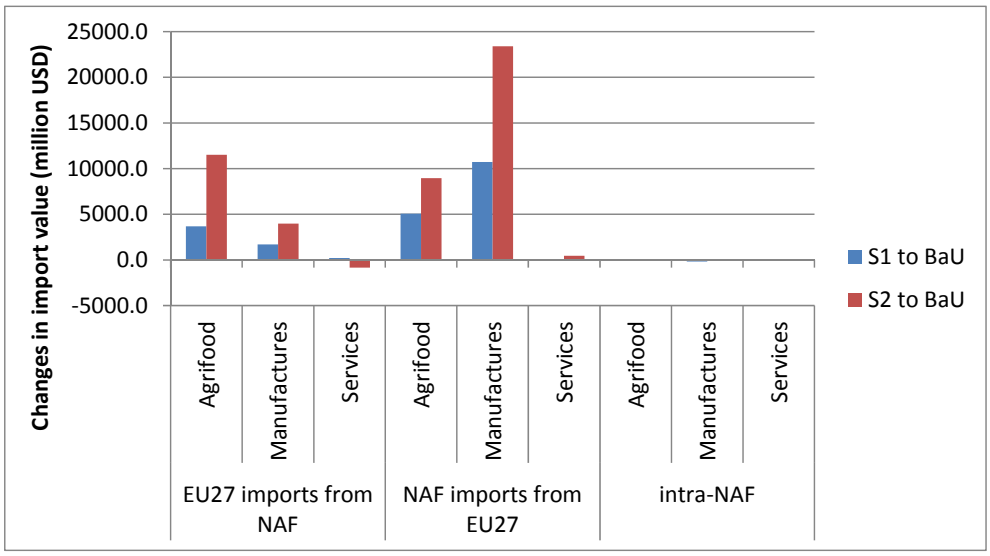
This section presents the results of the three simulation scenarios at the aggregated country level. Given the focus of the analysis, we look at the results for NAF countries and the EU27, with the rest of the world aggregated into main geopolitical regions, and concentrate on agri-food sectors, with other products aggregated into broad categories. The results refer to differences from the BaU scenario and are reported for the year 2020. The scenarios are evaluated separately as each one represents a different, hypothetical, future.

[5] See Appendix A.3 for a derivation of these shocks.

4.1 Results of trade liberalisation scenario

Figure 1 shows the differences between the trade liberalisation scenario and the BaU scenario in 2020 for bilateral imports between the EU and the three NAF countries under review (Egypt, Morocco and Tunisia) as well as across the NAF countries (intra-NAF). A first observation is that the results of tariff liberalisation (S1) are, overall, less prominent than the results of the tariff liberalisation and NTM reduction combined (S2). This is due to the modelled efficiency boost when lowering non-tariff barriers by the "iceberg-cost" approach but not when eliminating tariffs. Reducing NTMs involves a liberalisation that takes place behind the borders of the partner countries, as foreseen in the DCFTAs between the EU and NAF countries.

Figure 1 Trade liberalisation effects on imports, 2020



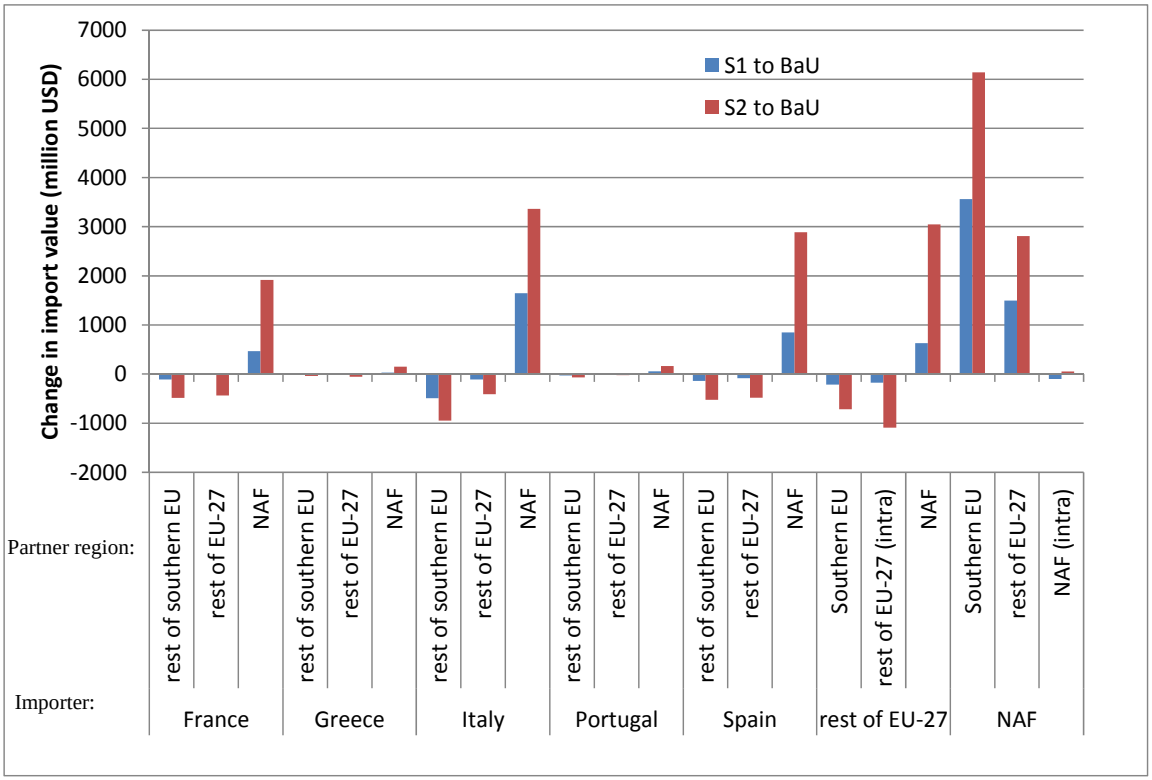
Source: MAGNET calculations.

EU27 imports of agri-food products from NAF countries approximately double under S1 and more than triple under S2. This is an increase of 3,680 million USD and 11,519 million USD, respectively. The increase in trade value varies across the commodities depending on the initial level of the ad-valorem tariffs. The highest increase is observed for vegetable oils and fats: EU27 imports from NAF countries increase by two times and four times under S1 and S2, respectively. This increase is because the import tariffs the EU27 imposes on NAF products are rather high (Table 3) and are eliminated in the simulation. EU27 fruit and vegetables imports from NAF countries and in particular from Morocco increase but the increases of EU27 fruit and vegetables imports is not as large as the increase of EU27 imports of vegetable oils and fats (increase of 24% under S1 and about a doubling under S2 especially from Tunisia).

NAF imports of agri-food products from the EU27 increase by 2020 from 4,719 million USD to 9,779 million USD under S1 and to 13,674 million USD under S2. This is linked to the initially higher import tariffs for food, beverages and tobacco in Egypt and cereals and animal products in Tunisia and Morocco. More precisely, imports of food, beverages and tobacco increase by 75% and 100% under S1 and S2 respectively. NAF wheat imports from the EU27 are more than three times and more than five times higher under S1 and S2 compared to BaU, respectively. The most remarkable increase is observed for imports of beef, sheep and horse meat, expanding from 9 million USD in the BaU scenario to 609 million USD under S1 and to 1,121 million USD under S2. These increases are the highest for Morocco and are less pronounced for Tunisia and Egypt.

Most of the agri-food trade expansion is realised in the southern EU Member States (Figure 2). Specifically, agri-food imports of France, Greece, Italy, Spain and Portugal together increase by 3,049 million USD under S1 and by 8,475 million USD under S2, which corresponds to 83% and 74% of the increase of the EU27 agri-food imports from NAF countries. NAF countries increase their imports from France, Greece, Italy, Spain and Portugal by 3.6 billion USD under S1 and by 6.1 billion USD under S2. The increase of imports from the rest of the EU27 is about 2 times less (1.5 billion USD and 2.8 billion USD under S1 and S2 respectively). As a result intra-EU trade declines by 1,396 million USD and by 5,273 million USD under S1 and S2 respectively. The decline involves trade flows both in the north-south and south-north axis as well as in the south-south and north-north axis, and is mainly because of lower intra-EU trade of fruit and vegetables and of processed food, beverages and tobacco. Regarding south-south trade, the decline is mainly for vegetable oils and fats. Italy reduces its imports of vegetable oils and fats mostly from Spain, and less from Greece, France and Portugal, whereas it increases its imports mainly from Tunisia and to a lesser extent from Morocco and Egypt. It should be noted that olive oil is grouped in the category vegetable oils and fats and hence these developments reflect the current olive oil trade flows around the Mediterranean; Italy is the major EU importer of bulk olive oil imported from Spain and Greece and to a lesser extent from NAF countries and is the main olive oil supplier of northern EU countries (Eurostat, 2012). It should also be noted that in relative terms the decline of intra-EU trade is rather limited. In fact, in this simulation the share of agri-food import from the southern EU Member States into the rest of EU27 did not change and the same holds for the share of agri-food imports from the rest of EU27 into France, Greece, Italy, Spain and Portugal.

Figure 2 Trade liberalisation effects on agri-food imports by source, 2020



Source: MAGNET calculations.

NAF imports of EU manufactured products expand by 44% under S2, and only by 20% under S1. The respective figures for EU imports of NAF manufactured products are 12% and 5%. These impacts seem to result from lower agri-food input costs for manufactures.

Trade liberalisation hardly results in any effects for trade amongst NAF countries (intra-NAF trade) which reflects the limited intra-NAF trade; imports into NAF from other Mediterranean countries were below 3% in 2007 (Eurostat, 2009). It is worth mentioning that in 2011, the EU imports of agri-food from Mediterranean countries (including NAF countries) accounted 5.9% of the total EU imports which translates to a share of the Mediterranean countries in EU imports of 7.2% (DG Trade, 2012). Note that in 2010, the EU27 was the main trade partner of the Mediterranean countries (including the NAF countries), where EU products made up for almost 40% of their total imports (DG Trade, 2012). We also observe that trade liberalisation between the EU27 and the NAF countries does not result in substantial trade diversion effects from the EU perspective.

Table 6 reports the effects of trade liberalisation on the production volume of the EU and of the NAF countries. Production expands in the EU for products that are demanded more by NAF countries (i.e. for which NAF imports increase the most), namely wheat, other cereals and livestock products, and decreases for the products with more import competition by products from NAF countries, namely vegetable oils and fats. In the EU, the production of vegetable oils and fats as well as wheat is affected the most. For vegetable oils and fat, production decreases mainly in the southern EU Member States; the decrease is about 7.3% under S1 and 14% under S2. For wheat, on the other hand, production increases in the EU27 by 5.7% under S1 and 8.1% under S2, with the increase in the southern EU Member States being slightly above this average.

The impact on production in the NAF countries is opposite to the impact on production in the EU. In the NAF countries, production declines for those products that face higher import competition by EU products. Production increases for the products which are demanded more by the EU. The results are most pronounced for wheat (-19% and -39% under S1 and S2, respectively), for vegetable oils and fats (130% and 217% under S1 and S2, respectively) and for beef, sheep and horse meat (12% and 24% under S1 and S2, respectively). Regarding manufactures, production of textiles and clothing increases by almost 2% in the NAF countries, and this is linked to the lower production costs and expansion of their exports into the EU27, as described above.

Table 6 Trade liberalisation effects on production volume, % differences from BaU, 2020

	EU27		Southern EU		Rest of EU27		NAF	
	S1	**S2**	**S1**	**S2**	**S1**	**S2**	**S1**	**S2**
Agri-food	0.1	0.0	0.2	0.0	0.1	0.0	-2.6	0.4
of which:								
- Rice paddy	-1.0	-2.8	-0.9	-2.5	-2.2	-7.5	2.5	5.4
- Rice milled	-2.6	-6.7	-1.9	-5.1	-3.9	-10.1	4.3	8.0
- Wheat	5.7	8.1	7.4	11.3	4.1	5.0	-19.2	-38.9
- Other cereals	0.5	0.7	0.5	0.9	0.5	0.5	-1.4	-1.8
- Sugar cane & beet	-0.2	-0.2	1.0	3.9	-1.0	-3.0	2.3	8.5
- Sugar	-0.3	-0.6	1.0	4.0	-1.1	-3.3	6.5	18.4
- Fruit & vegetables	-0.8	-3.1	-1.0	-3.6	-0.6	-2.4	2.9	10.7
- Oilseeds	-3.3	-5.9	-5.3	-9.7	-0.8	-1.3	2.6	4.3
- Vegetable oils/fats	-3.5	-6.6	-7.3	-14.0	-0.7	-1.1	130.3	217.1

- Dairy products	0.1	0.2	-0.1	-0.1	0.2	0.4	-6.0	-8.6
- Meat beef, sheep, goat, horse	1.0	1.9	2.2	3.9	0.0	0.1	-12.2	-23.7
- Meat pork, poultry, other	-0.1	-0.1	-0.1	0.1	-0.1	-0.3	-2.1	3.3
- Food, beverages, tobacco	0.2	0.1	0.3	0.2	0.2	0.0	-9.8	-5.7
Manufactures	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	-3.1
of which:								
- Textiles and clothes	0.3	0.4	0.4	0.7	0.1	0.1	2.0	2.3
- Petroleum and coal products	0.1	0.1	0.1	0.2	0.1	0.1	-0.9	-2.0
Trade services &	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.9
communication								
Transport	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.2

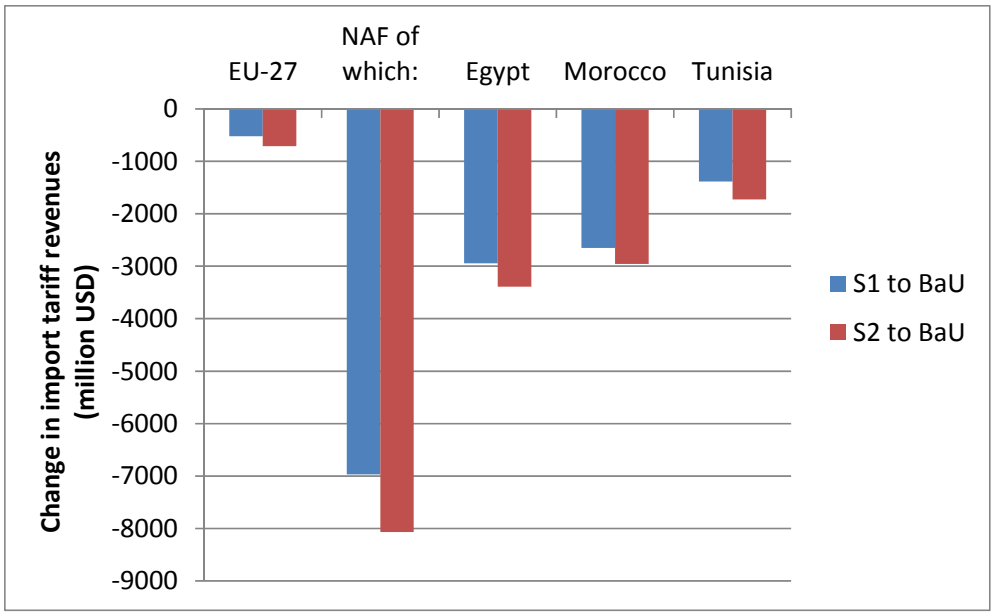
Source: MAGNET calculations

Looking at food security indicators[6], household consumption increases in the NAF countries by 4% and 9% under S1 and S2 respectively as consumers' food prices decrease by about the same magnitude. Consumption of domestic food in the NAF countries however decreases by 6% (S1) and 11% (S2), while consumption of imported agri-food products increases by almost 80% (S1) and by about 160% (S2). Since total household consumption increases by relatively little on the one hand, and consumption of imported food increases by a lot on the other hand, it suggests that imported agri-food products are not so important in the household food basket compared to domestic products. However, these results do point out that the NAF countries become more dependent on imports for satisfying their food demands. In conclusion, trade liberalisation boosts total household consumption of food and can hence be seen as enhancing food security in the NAF countries, but it should be noted that at the same time import-dependence increases and as a result NAF countries become more vulnerable to price fluctuations on the world market.

Bilateral trade liberalisation affects government revenues and results in a reduction of import tariff revenues (Figure 3). The decrease depends on the initial level of the import tariffs and on how imports changed (increased or decreased) because of trade liberalisation. For the EU27 the reduction of import tariff revenues is of 1% and 1.5% under S1 and S2 respectively, whereas for the NAF countries it is of 52% and 60% under S1 and S2 respectively. These results outline the relatively high importance of the EU as trade partner for NAF countries and the relatively low importance of NAF countries as trade partner for the EU. Among the NAF countries, the highest fall of import tariff revenues is realised in absolute terms in Egypt (fall of 2,943 million USD under S1 and 3,392 million USD under S2) and in relative terms in Tunisia (the observed fall of 1,384 million USD under S1 and of 1,729 million USD under S2 is equivalent to 57% and 70% of Tunisia's import tariff revenues in the BaU scenario).

[6] Food security is most commonly defined as "…when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (definition by FAO: http://www.fao.org/docrep/013/al936e/al936e00.pdf). A variable for food security does not exist in GTAP or MAGNET, but we take it that a rise (fall) in the consumption of food, which could originate from changes in domestic supply or imports, represents an improvement (deterioration) in food security. When reporting outcomes in terms of consumption or consumer prices we show consumption and prices faced by households, the group of consumers the government is mostly concerned with when it comes to food security.

Figure 3 Trade liberalisation effects on import tariff revenues , 2020



Source: MAGNET calculations.

Table 7 reports the effects of trade liberalisation on GDP. Overall, there are GDP gains, but they are very small and most pronounced when both tariffs are eliminated and NTMs are reduced (S2). This holds in particular for the EU. The change in GDP is relatively larger for NAF countries and the effects are more pronounced under S2. Comparing S1 and S2, only 23% of NAF's total GDP gains under S2 is already achieved under S1, suggesting that 77% is because of the combined effect of tariff elimination and NTM reduction. In southern EU 20% of GDP gains are achieved already under S1 and for the rest of EU27 this is 50%.

Table 7 Trade liberalisation effects on GDP, 2020

	% difference from BaU	
	S1	S2
EU27	0.01	0.03
Southern EU	0.01	0.05
Rest of EU27	0.01	0.02
NAF	0.64	2.73

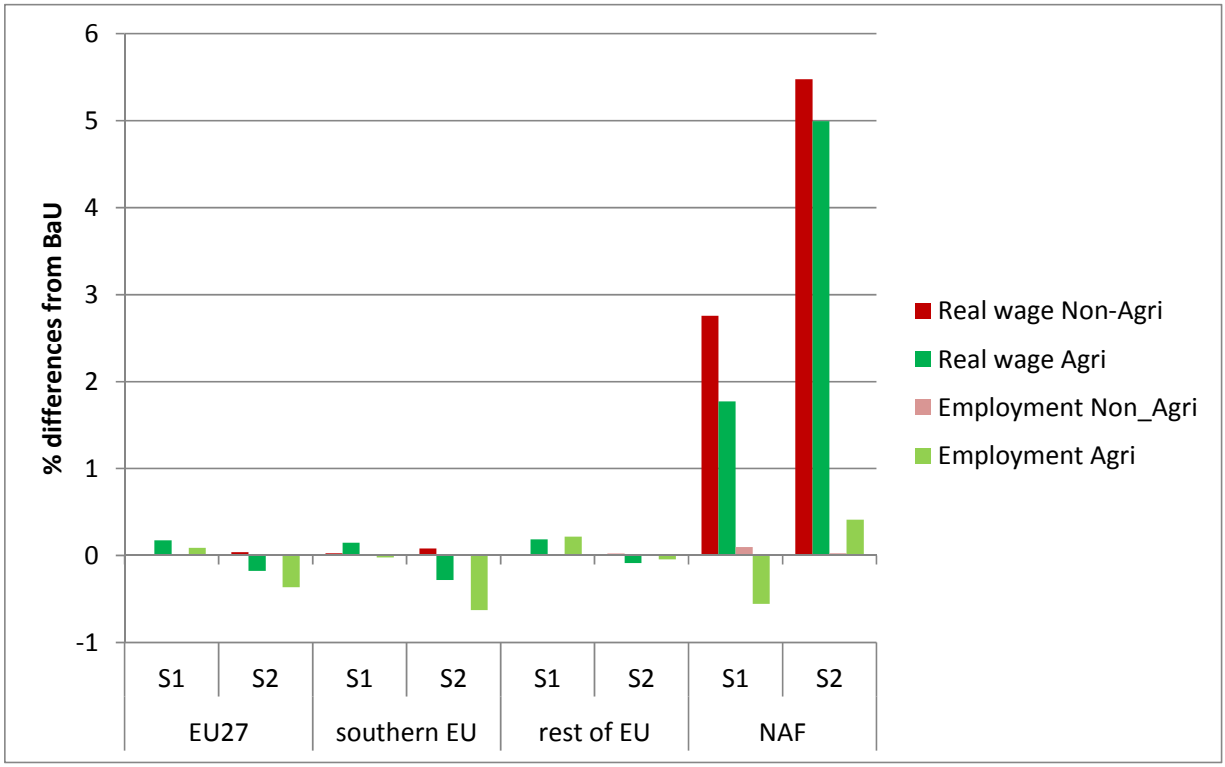
Source: MAGNET calculations.

Figure 4 shows the impact of trade liberalisation on employment and wages in agricultural and non-agricultural sectors. The employment and wage changes follow the changes in production observed earlier in this scenario. In the EU, employment in agriculture in S1 slightly goes up, and as a result real agricultural wages also go up slightly (mostly in rest of the EU), whereas in S2 employment and real wages in agriculture fall (mostly in Southern EU). In S1, due to tariff liberalisation the rest of EU benefits from increased wheat production and exports to NAF countries, which draws in more employment. In S2, due to a reduction in NTMs, Southern EU countries experience higher import competition from vegetable oils and fats which goes at a cost of domestic production and employment. The latter effect outweighs the positive effect on the wheat sector in terms of employment.

In NAF countries, the effects on wages and employment are more pronounced. Employment in agriculture decreases under S1, but increases under S2. In S1, due to tariff liberalisation NAF countries wheat production contracts, which outweighs the increases observed in production of other primary agricultural sectors in terms of employment. In S2, the reduction in NTMs result in a higher

increase in the more labour demanding primary agricultural sectors (fruit and vegetables and oil seeds). This outweighs the contraction of the wheat sector and resulting loss in employment. These results confirm that NAF countries can realise efficiency gains by reducing trade barriers behind the border, giving a boost to agricultural production and employment.

Figure 4 Trade liberalisation impacts on employment and real wages, 2020



Notes: Agriculture: pdr, wht, gro, v_f, osd, c_b, pfb, ocr, ctl, oap, rmk, wol; Non-agriculture consists of the remaining sectors. See Table 1 for sector full names.
Source: MAGNET calculations.

Finally, both wages in agriculture and non-agriculture rise, with the increase being more pronounced in the non-agricultural sector. This is because processed food commodities (for example vegetable oil and fats) are not part of primary agriculture and fall in the category of non-agriculture in the model's factor market segmentation. Production of these commodities in S2 increases, which draws in more labour in non-agriculture and puts upward pressure on real wages. These results suggest that rural households engaged in primary agricultural activities in NAF countries will be better off if trade liberalisation does not involve only tariff elimination (S1) but also reduction of NTMs (S2). Combined with the positive impacts observed with respect to food security (higher household consumption of food at lower prices), this seems to suggest that rural households have become less vulnerable.

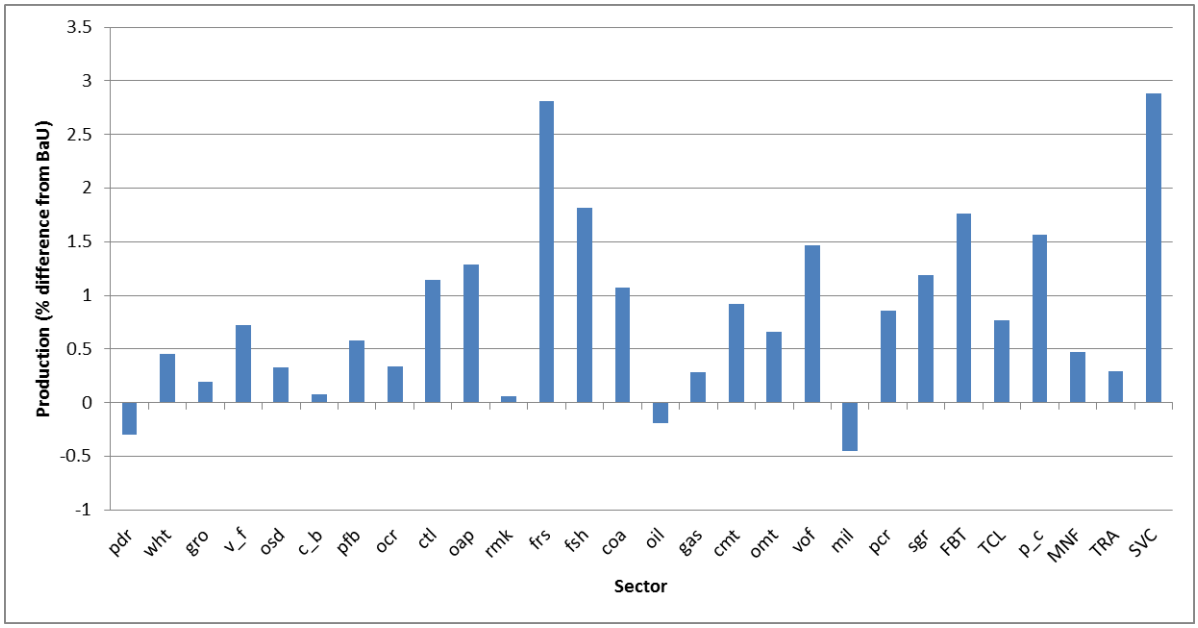
4.2 Results of broad productivity gain scenario

This section presents the results of the BI scenario, in difference from the BaU. The BI scenario assumes an increase of FDIs and capital flow in the NAF countries. A TFP growth of 1.5% over the period 2012-2020 in NAF countries, leads to a higher GDP (and GDP per capita) of 3.5% on average in 2020 (in difference from the BaU). Other countries and regions in the world are not affected in terms of GDP growth and therefore not shown (impacts less than 0.01%). The same is observed for production, employment, incomes and consumption impacts. We thus concentrate on the outcomes for the NAF countries as a whole. Figure 5 shows how production across sectors in NAF countries is affected, at the most detailed sectoral level. Almost all sectors benefit, with the exception of wool,

paddy rice, oil and milk sectors. Comparing relative growth rates, services and manufacturing/processed sectors benefit more than primary agricultural sectors, which is a similar trend as what is happening under the BaU.

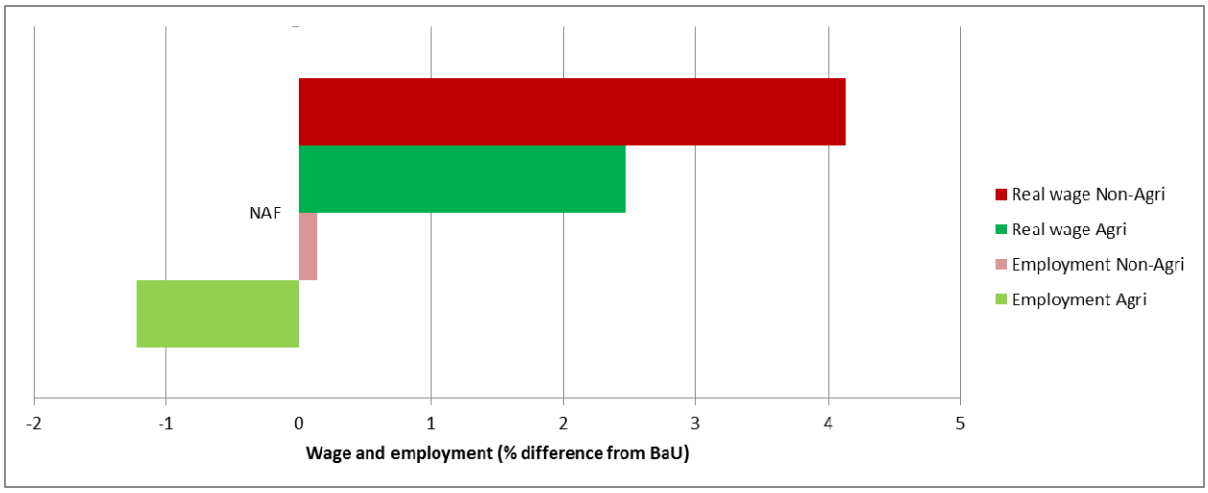
Sectoral employment impacts are roughly the same across NAF countries and change in favour of non-agricultural sectors (goes up by 0.1% for NAF countries on average), at a cost of employment in agriculture (falls by 1.2%) as presented in Figure 6. As a result of the real wages in non-agricultural sectors rise faster than real wages in agricultural sectors (growth of 4.1% and 2.5% respectively).

Figure 5 BI scenario impacts on production of NAF countries, 2020



Note: see Table 1 for sector full names.
Source: MAGNET calculations.

Figure 6 BI scenario impacts on the labour market of NAF countries, 2020

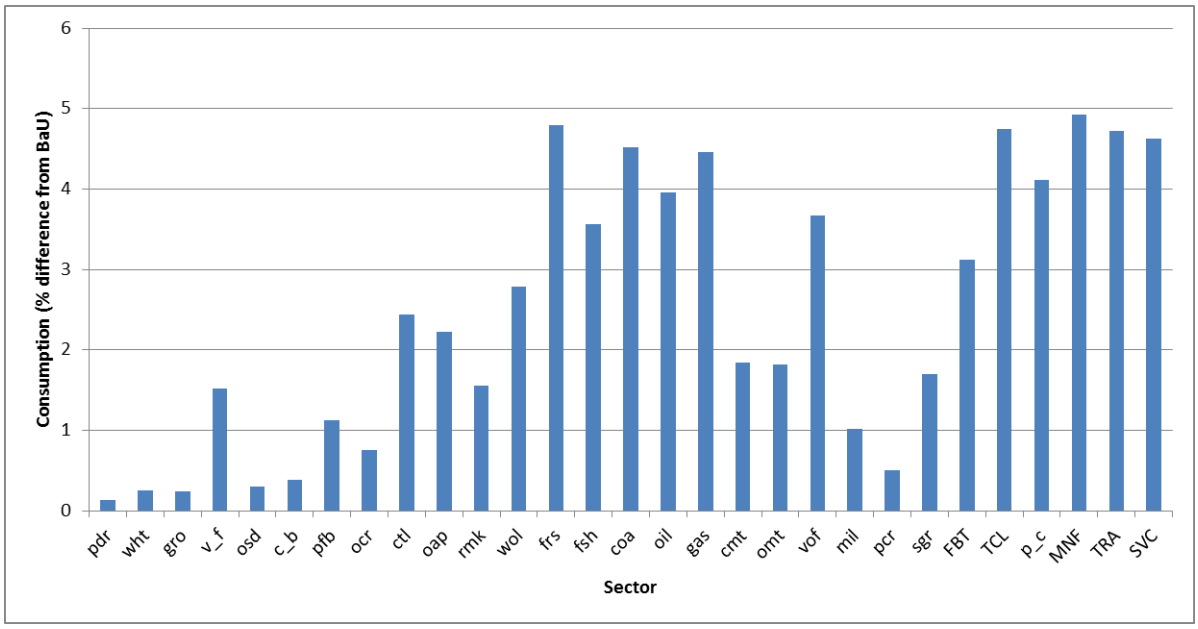


Source: MAGNET calculations.

The higher incomes in NAF countries are expected to benefit consumption, and the results show that this is indeed the case (Figure 7). Household consumption of all commodities on average goes up by 3.9%, but most of this is attributable to manufacturing and services categories (bars on the middle and on the right). With respect to food, growth in household consumption of grains (0.1 to 0.2%) lags behind compared to more nutritious food items such as milk products (1%), fruit and vegetables

(1.5%), meat products and sugar (around 1.8%), other food, beverage and tobacco (3.1%), and fish and vegetable oils and fats (3.6%). This reflects expected trends in diets.[7] Focussing in more detail on food security in NAF countries, we observe that in this scenario NAF's household consumption of food items, improves slightly by 2%. This improvement stems from domestic and a little more from imported sources. NAF households nonetheless pay a higher price for their food (over 1% on average).

Figure 7 BI scenario impacts on household consumption of NAF countries, 2020



Note: see Table 1 for sector full names.
Source: MAGNET calculations.

Last, NAF country imports in the BI scenario grow faster for non-agricultural commodities (Table 8), whereas on the export side the opposite is true as is visible from higher growth rates for agricultural commodities, most notably wheat. This results in a deterioration of NAF's trade balance; the higher growth fuels the need for industrial and services imports. In this scenario the trade balance of NAF countries vis-à-vis the EU deteriorates by 2.9 billion USD in total.

In conclusion, the BI scenario seems to magnify the results of the baseline, i.e. services and manufacturing/processed sectors grow higher than primary agricultural sectors. This result seems key if one considers that in Arab countries, manufacturing and services-led growth is more pro-poor than agriculture-led growth (IFPRI, 2012).

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[7] See also description of consumption structure of MAGNET in Appendix A.3.

Table 8 BI scenario impacts on NAF imports, exports and balance of trade with NAF and EU27, 2020

Indicator	Sectors:	pdr	wht	gro	v_f	osd	c_b	cmt	omt	vof	mil	pcr	sgr	FBT	TCL	p_c	MNF	TRA	SVC	All Comm
NAF imports (% difference) from:	NAF	-4.5	5.8	-1.2	1.4	-3.2	-2.2	0.7	13.1	4.0	-2.9	9.8	2.6	0.5	-3.3	3.4	0.8	-2.8	-2.8	0.9
	EU27	-0.7	-0.4	-0.3	0.9	0.3	0.5	6.4	12.5	0.8	4.5	5.5	1.1	2.0	1.2	-0.1	2.4	4.1	4.4	2.3
	Southern EU	-0.7	-0.3	-0.1	1.0	0.3	0.5	8.9	13.1	0.5	3.2	5.6	1.1	2.3	1.1	-0.1	2.7	4.0	4.6	2.4
	Northern EU	-0.7	-0.6	-0.5	0.9	0.4	0.5	2.7	11.4	1.4	5.0	1.7	0.8	1.9	1.4	-0.1	1.9	4.1	4.3	2.3
NAF exports (% difference) to:	NAF	-4.5	5.8	-1.2	1.4	-3.2	-2.2	0.7	13.3	3.9	-2.9	9.8	2.6	0.5	-3.3	3.4	0.8	-2.8	-2.8	0.9
	EU27	-3.3	4.3	-0.3	-0.4	-2.3	-1.2	-5.5	1.4	0.0	-7.0	2.6	-0.2	-1.7	-1.8	3.3	-2.2	-7.1	-7.3	-3.1
	Southern EU	-3.3	4.3	-0.2	-0.3	-2.4	-1.2	-5.5	-1.5	0.0	-6.4	2.6	0.1	-1.6	-1.3	3.3	-2.2	-7.1	-7.3	-2.0
	Northern EU	-3.3	4.3	-0.3	-0.8	-2.2	-1.2	-5.5	4.0	1.3	-7.3	2.5	-0.5	-1.7	-3.0	3.3	-2.2	-7.1	-7.3	-4.7
NAF trade balance (million USD difference) with:	NAF	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	-0.1	0.0	-0.1	-0.1	-0.1	0.1	-0.4	-0.8	0.0	0.0	-1.7
	EU27	-0.1	3.2	0.6	-6.9	-0.3	0.0	-2.2	-0.8	-0.7	-16.0	0.8	-0.3	-45.2	-224.5	46.8	-1319.3	-569.4	-685.8	-2869.4
	Southern EU	0.0	1.0	0.1	-3.2	-0.2	0.0	-0.8	-1.3	-0.5	-3.2	0.2	-0.2	-28.2	-123.4	35.6	-874.9	-173.0	-188.4	-1391.2
	Northern EU	-0.1	2.1	0.5	-3.8	-0.1	0.0	-1.4	0.5	-0.2	-12.7	0.7	-0.1	-17.0	-101.1	11.2	-444.4	-396.4	-497.4	-1478.2

Note: see Table 1 for sector full names.

Source: MAGNET calculations.

4.3 Results of targeted productivity gain scenario

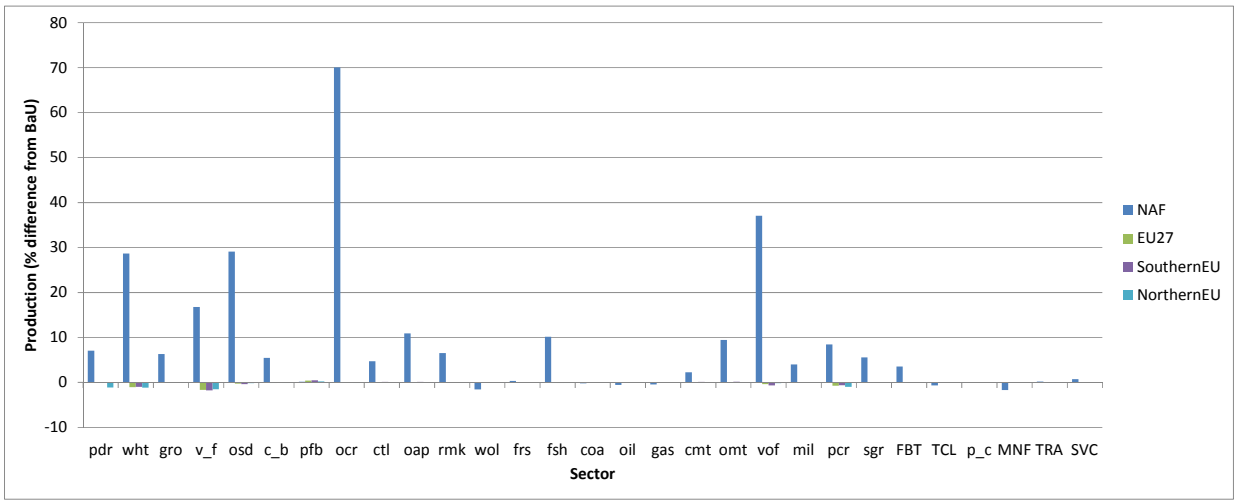
This section presents the results of the TI scenario, in difference from the BaU scenario. The TI scenario focuses on obtaining a higher agricultural growth path in NAF countries, by improving efficiency in agricultural production and post-harvest handling and storage, and so reducing food waste. It thus assumed an increase of targeted public and private investments.

A TFP growth in North African agricultural sectors in the range of 7% to 30% (Table 5) over the period 2012-2020, leads to a higher GDP (and GDP per capita) in North African countries of 2.3% on average in 2020 (in difference from the BaU). Other countries and regions in the world are not affected in terms of GDP growth and therefore not shown (impacts less than 0.01%).

Impacts are different across sectors (Figure 8). Primary sectors of NAF countries that increase total factor productivity by reducing losses in production, handling and storage, experience an increase in production. Other crops, wheat and oil seeds seem to benefit most (production increases by close to 70% and 30% respectively), followed by fruit and vegetables (increase of 17%). As these commodities become cheaper, sectors using these commodities as intermediate input in production also benefit, as is shown by growth in the various processed food categories. Production of vegetable oils and fats expands most (37%). With primary sectors expanding, resources flow out of other sectors in NAF countries, notably other manufacturing which contracts by 1.7%.

As the NAF region produces more primary commodities for the market at lower cost, the EU27 primary production decreases. Most notably the vegetables, fruit and vegetables and wheat sectors suffer from a loss in competitiveness and contract by 1.7% and 1% respectively.

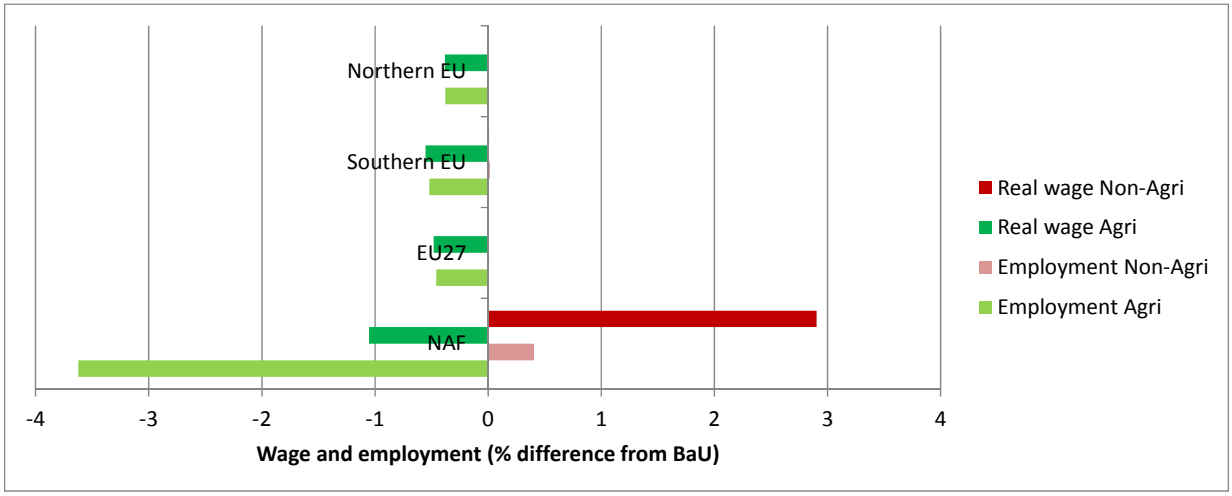
Figure 8 TI scenario impacts on production, 2020



Note: see Table 1 for sector full names.
Source: MAGNET calculations.

Agricultural employment in the North African region declines by 3.6% on average due to more efficient production so that less inputs are needed, including labour (Figure 9). Real wages in agriculture also fall (by 1% on average). This benefits non-agricultural sectors in terms of both employment and real wages, which rise by 0.4% and 2.9% on average. In the EU the loss in competitiveness in agriculture also translates into lower employment and real wages (both fall by 0.5% on average).

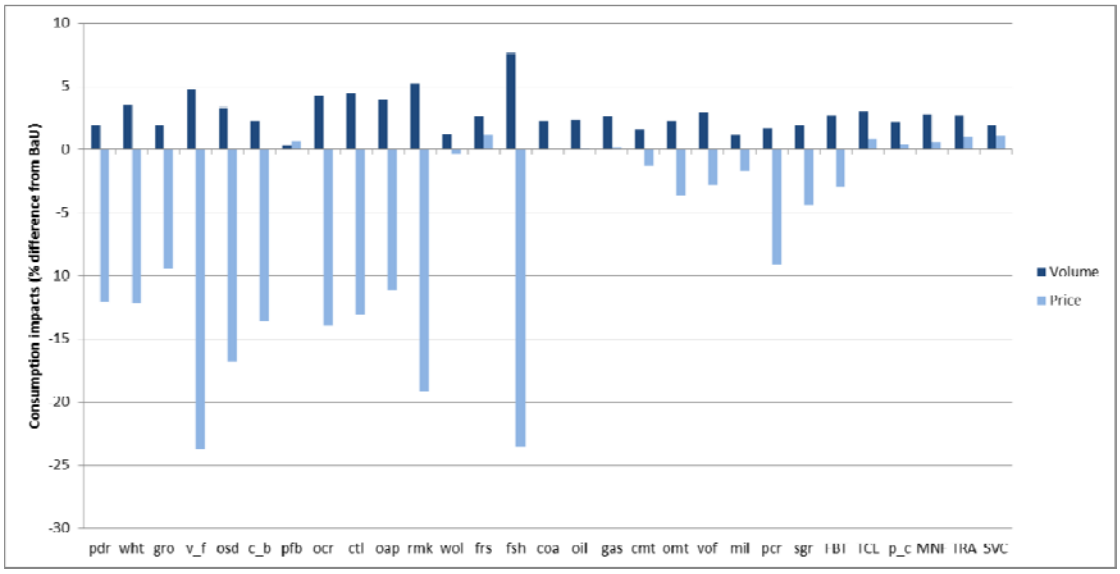
Figure 9 TI scenario impacts on the labour market, 2020



Note: Agriculture: pdr, wht, gro, v_f, osd, c_b, pfb, ocr, ctl, oap, rmk, wol; Non-agriculture consists of the remaining sectors. See Table 1 for sector full names.
Source: MAGNET calculations.

The changes on the labour markets and other factor markets combined influence income and so consumption. Prices also matter. We observed that GDP per capita in the NAF region is going up. We also observed that agricultural sectors in NAF countries are producing more due to more efficient production (lower waste or losses).

Figure 10 TI scenario impacts on household consumption of NAF countries, 2020



Note: see Table 1 for sector full names.
Source: MAGNET calculations.

Figure 10 displays the impacts on household consumption and market prices in NAF countries. It shows that, for primary and processed food sectors consumers face much lower market prices and, combined with higher (real) incomes, increase consumption. Consumption rises particularly for fish, raw milk and vegetables, fruit and vegetables (increases of 7.6%, 5.2% and 4.8% respectively), which reflects the gains in efficiency and so lower costs and prices of primary production, as well as the expected trends in diets (away from staple foods towards more nutritious food).

Given aforementioned developments, we expect that food security in the NAF region improves. Specifically, improved agricultural efficiency leads to a higher household consumption of food (increases by 3.1%) at lower food prices on the market (fall by 9.6% on average). Taking into account the previously observed labour market impacts, rural households who suffer from lower wages and employment, may well be worse off as their fall in income may outweigh the fall in food price. The observed rise in household food consumption may be only true for the urban households. When looking at the source of food consumption, it becomes clear that whilst food consumption from a domestic origin goes up (by 5.5%), that from abroad goes down (by 15.5%). There is thus some substitution away from imported food products which reduces the North African dependence on and vulnerability to the world market. Specifically, imports of agri-food commodities by NAF countries fall (not shown), whereas exports rise even more so, resulting in an improvement in NAF's trade balance in agri-food commodities. However, in other sectors, notably other manufacturing, this process is exactly reverse, with imports rising and exports falling so that in total NAF's trade balance deteriorates vis-à-vis the EU by 1 billion USD.

5. Concluding remarks

This paper aims at providing some insights into how one may potentially promote growth after the recent political turmoil in the south-Mediterranean region. Simulations are viewed within the process of the EuroMed integration and are framed within expected DCFTAs between the EU27 and respectively Egypt, Morocco and Tunisia. Table 9 summarises the effects of each scenario on growth, labour market and food security in the NAF countries, and draws three sound concluding remarks.

Table 9 Trends of the impacts on growth, labour market and food security of different scenarios for NAF countries*

Scenario	Trade liberalisation (TL)**	Broad investment (BI)	Targeted investment (TI)
GDP	+	++	+
Employment:			
• Agriculture	+	-	-
• Non-agriculture	+	+	+
Real wages			
• Agriculture	+	+	-
• Non-agriculture	+	+	+
Household consumption of food (per capita)	+	+	+
• Domestic food	-	+	+
• Imported food	++	+	-
Household prices	-	+	- -

Note: * Since the shocks and reference scenario differ, the table shows only trends; magnitudes of effects cannot be compared. The trends refer to the end-point difference in percentage changes in 2020; + indicates an increase and ++ indicates more pronounced increase; – indicates a decrease in the simulation result; - - indicates a more pronounced decrease; ** The TL scenario refers to the impacts of eliminating import tariffs and reducing NTMs (S2).
Source: authors own compilation.

First, each scenario grants a positive impact on GDP, with higher growth in NAF countries of about 2.7% (TL), 3.5% (BI) and 2.3% (TI) on average in 2020. Economic growth is stimulated mostly by a productivity boost, and effects are deeper if productivity gains involve all sectors of the economy and

are not targeted to the agricultural sector. Growth is also boosted by trade liberalisation (TL scenario) which makes NTMs removal a key issue of further trade integration between the EU and NAF countries. This suggests that positive impacts on economic growth could be intensified by combining policies aiming to foster both productivity gains and trade flows.

Second, the results confirm that as the economy of NAF countries grows, less labour is demanded by agricultural sectors and real wages in agricultural sectors increase. Specific agricultural productivity growth reduces agricultural employment and wages (TI scenarios) which may have negative implications for rural households that are likely to be more dependent on primary agricultural sectors. However positive effects on agricultural employment may emerge if productivity growth is combined with trade liberalisation. The latter aligns with the objectives of the DCFTAs that specifically foresee not only trade liberalisation but also heighten investment flows so as to promote growth and efficiency gains.

Third, looking at food security indicators, higher economic growth leads to more demand for food and thus to higher prices. Trade liberalisation enhances food security and counteracts the rising food prices, however the dependence on and vulnerability to changes in the world market rises. Increasing agricultural productivity and cutting down losses and waste in food production, improved storage and handling can be considered as being a first step to reduce dependence on and vulnerability to world food markets, while reinforcing food security by lowering prices and increasing food consumption of households in NAF countries. It remains to be seen whether national policies will be able to adopt strategies that enhance food security at household level.

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7. Appendix

A.1: Brief description of the GTAP model

The GTAP model, which is well documented by Hertel (1997) and Brockmeier (1996), captures the behaviour of three types of agents: households, firms and government, in each country or region of the world. Households' behaviour is captured via a 'representative regional household', which in search for maximising its utility, collects all income that is generated in the economy and allocates it over private household and government expenditures on commodities, and savings for investment goods. Income comes from payments by firms to the regional household for the use of endowments of skilled and unskilled labour, land, capital and natural resources. The regional household also receives income from (net) taxes paid by the private household (on private consumption and income), firms (taxes on intermediate inputs and production) and the government (on its expenditures). Firms, in search for maximising profits, produce commodities by employing the aforementioned endowments and intermediate inputs from other firms using constant returns to scale production technology[8] so as to sell them to private households, the government and other producers. Domestically produced goods can either be sold on the domestic market or to other regions in the world. Similarly domestic intermediate, private household and government demand for goods can be satisfied by domestic production or by imports from other regions in the world (Armington assumption). These come with specific import and export taxes. Sourcing of imports happens at the border, after which – on the basis of the resulting composite import price – the optimal mix of import and domestic goods is derived.

With all markets in equilibrium, firms earning zero profits and households being on their budget constraint, global savings must equal global investments. Investments are computed on a global basis, via a 'global bank' which assembles savings and disburses investments, so that all savers in the model face a common price for this savings commodity. In GTAP, global savings determine global investments, i.e. the macro closure is savings driven and essentially neoclassical in nature. Since the CGE model can only determine relative prices, the GDP deflator is set as the numéraire of the model, against which all other prices are benchmarked. Changes in prices resulting from the model simulations thus constitute real price changes. Since GTAP is essentially a comparative static model, investments only influence the pattern of production (via investments as a demand category) and are not installed so as to add to the productive capacity of industries over time.

A.2: Main feature of the MAGNET model

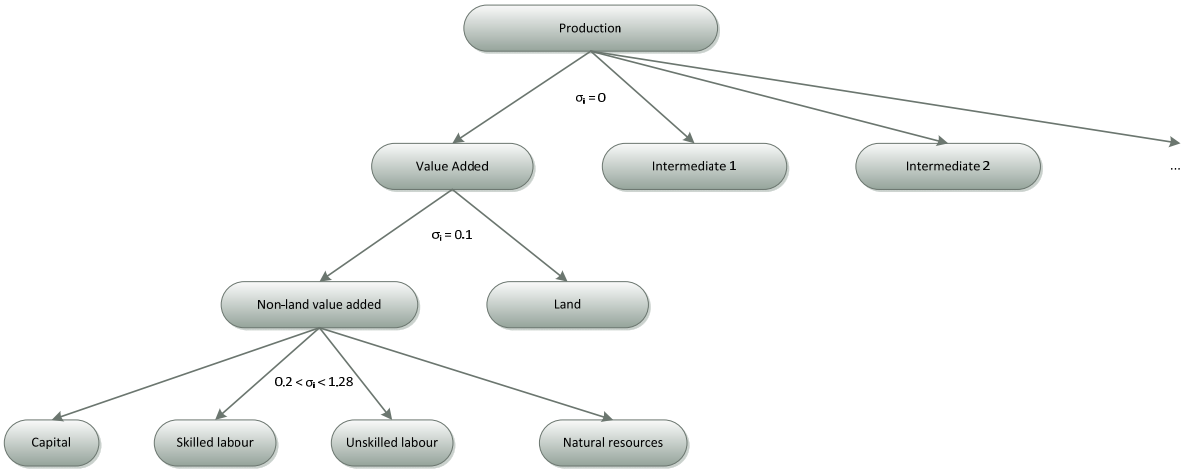
Production structure

The MAGNET model has a flexible Constant Elasticity of Substitution (CES) nesting structure for production, according to which the ease with which different inputs into production may be substituted in the production of final goods, as measured by the substitution elasticities, may differ across nests. Whereas different sectors may have different nesting structures, for this project a simple three-level nesting structure has been chosen for all sectors and in all countries/regions of the world. Specifically, in the top nest value added and intermediate inputs are combined into production. In the second nest,

[8] This means that as firms grow, they do not become more or less efficient.

land and non-land value added are combined into value added. In the third nest, capital, skilled and unskilled labour and natural resources are combined into non-land value added. The distinction between land and non-land value added, to account for inherent differences in the degree of substitutability between land and non-land factors, is new relative to standard GTAP. The value of the elasticity of substitution increases as we go down in the tree structure as inputs used in production become more similar (and so can more easily substituted). In the top nest, the substitution elasticity is assumed zero (as in standard GTAP), so that inputs cannot be substituted and are used in production according to fixed input-output coefficients. In the value added nest, the substitution elasticity equals 0.1 and in the non-land value added nest in between 0.2 and 1.28 depending on the commodity in question (Figure A.1).[9]

Figure A.1 MAGNET production structure



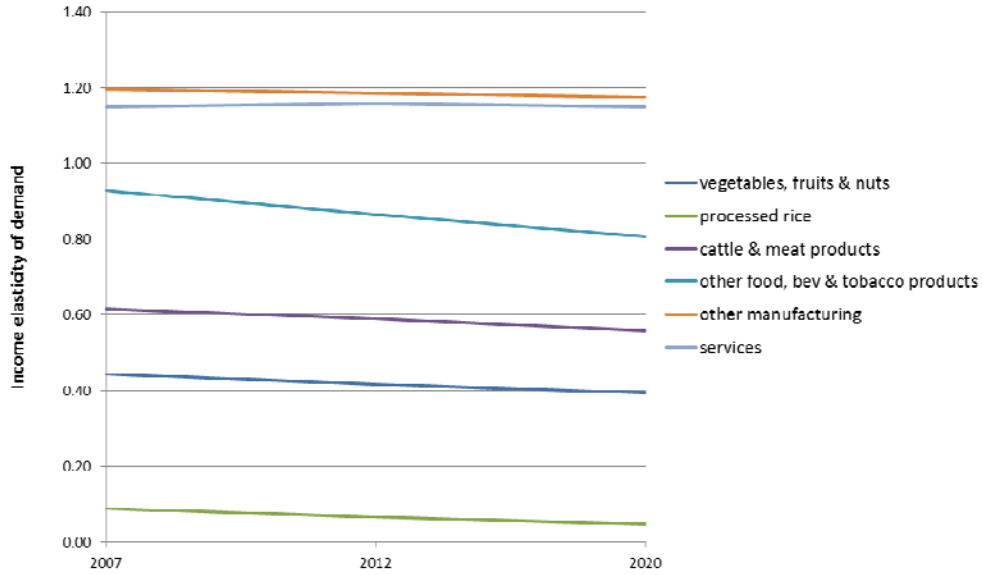
Source: own illustration.

Consumption structure

In GTAP private (household) consumption behaviour is modelled via a Constant Difference of Elasticity (CDE) function, which is a more flexible, non-homothetic function allowing for non-constant marginal budget shares, and is calibrated using data on income and price elasticities of demand. Since the use of the CDE function in practice results in constant income elasticities over time – leading to unrealistically high consumption of food items in fast growing economies – in MAGNET income elasticities are dynamically adjusted using real GDP per capita (in the form of a decreasing function). The services sector is used as a residual to guarantee that the sum of the income elasticities is 1. The updating of income elasticities takes place in each step of the Euler optimisation routine used in solving the model, and preserves the welfare calculations as present in the GTAP model. Starting values for the income elasticities are between 0 and 1 or slightly negative for agri-food products, and exceed 1 for manufacturing and services sectors. Figure A.2 illustrates the updating of income elasticities in the baseline (Business as Usual) scenario for Egypt, for a selection of commodities.

[9] An elasticity of substitution of x, implies that as the relative price of an input rises by 1%, its relative demand falls by x%.

Figure A.2 Example of income elasticities in MAGNET, baseline BaU scenario for Egypt

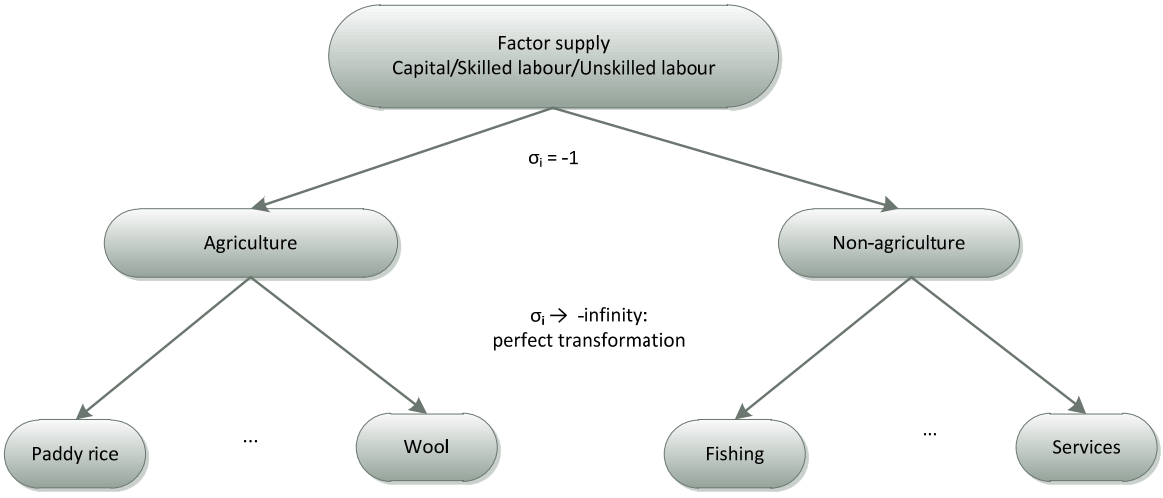


Source: own simulations with MAGNET.

Segmented labour and capital markets

In standard GTAP, capital and labour are assumed to be fully mobile across sectors. In reality, however, there's limited movement of capital and labour between agricultural and non-agricultural sectors, in contrast to relatively free movement within these sectors. This is evident from, for example, the differences in wage levels for unskilled labour in agriculture compared to industry and services sectors. MAGNET allows for the modelling of such segmented factor markets, by introducing a nested Constant Elasticity of Transformation (CET) function for capital and labour, which includes a nest for agriculture and non-agriculture (Figure A.3). Within these nests, capital and labour are assumed to be perfectly mobile, but between these nests it is more difficult to move. A consequence of this approach is that unskilled and skilled) labour and capital receive different remunerations (i.e. wage and rental rate respectively) in agricultural and non-agricultural sectors. The elasticity of transformation, which governs the sluggishness of movement of these factors across sectors, is set at a level of -1.[10]

Figure A.3 Segmented factor markets in MAGNET



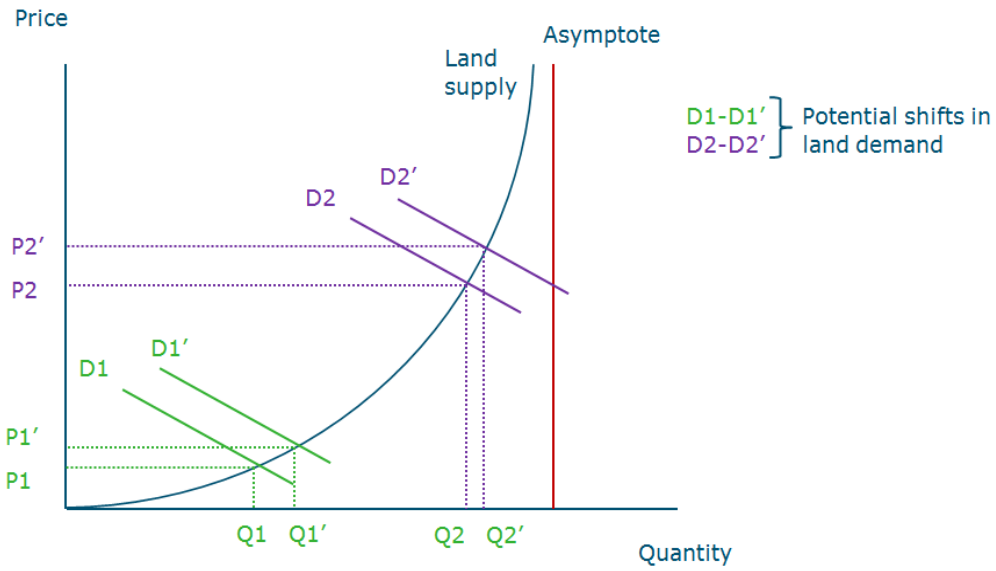
[10] An elasticity of transformation of –x implies that as the relative price of a factor rises by 1% its relative supply rises by x%.

Endogenous land supply

In standard GTAP, total land supply is fixed and is assumed to adjust sluggishly between sectors (as for natural resources). MAGNET allows for the incorporation of endogenous land supply by which overall land supplied to (and used in) agriculture is positively depending on a land price (the average of all land rental rates; Eickhout et al., 2009). This specification is depicted in Figure A.4.

The general idea underlying the land supply curve specification is that the most productive land is first taken into production. However, the potential for bringing additional land into agriculture is limited. The shape of the land supply function is governed by an asymptote, the maximum amount of land that is potentially available for agriculture, and a price elasticity of total land supply (and use). Closer to the asymptote the land price will increase by more as land use increases.

Figure A.4 Endogenous land supply in MAGNET



A.3: Shocks applied in the targeted productivity gain scenario (TI)

Total factor productivity shock so as to reduce losses (waste) in NAF countries' agricultural production, post-harvest handling and storage

Starting point is the FAO data on waste percentages in each step of the food supply chain for the region of North Africa, West and Central Asia (see below).

Estimated/assumed waste percentages for each commodity group in each step of the FSC for North Africa, West&Central Asia.

	Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution	Consumption
Cereals	6%	8%	2%, 7%	4%	12%
Roots & Tubers	6%	10%	12%	4%	6%
Oilseeds & Pulses	15%	6%	8%	2%	2%
Fruits & Vegetables	17%	10%	20%	15%	12%
Meat	6.6%	0.2%	5%	5%	8%
Fish & Seafood	6.6%	5%	9%	10%	4%
Milk	3.5%	6%	2%	8%	2%

Source: FAO (2011), Global Food Losses and Food Waste, Annex 4

If we translate this into the GTAP commodities we get:

Waste %	**Qo**	**H&S**	**P&P**	**D**	**C**
pdr	6	8	4.5	4	12
wht	6	8	4.5	4	12
gro	6	8	4.5	4	12
v_f	17	10	20	15	12
osd	15	6	8	2	2
c_b	6	10	12	4	6
ocr	17	10	20	15	12
ctl	6.6	0.2	5	5	8
oap	6.6	0.2	5	5	8
fsh	6.6	5	9	10	4
rmk	3.5	6	2	8	2

Notes:
Roots & tubers in GTAP is part of fruits & veg and sugar cane & beet. We map it to the latter category. Other crops are assumed to take the waste percentages for vegetables and fruits. We may thus overestimate the waste here slightly.
For processing and packaging cereals we have taken the average of the two percentages. Qo stands for production, H&S Handling and Storage, P&P Processing and Packaging, D Distribution C Consumption.

The next step is to apply these waste percentages to the GTAP data.

Assumptions:
(1) focus only on waste in (primary) agricultural production and post-harvest handling and storage (columns of Qo and H&S)
(2) GTAP data on production represents what is left over *after* waste in production, so that the waste percentage in production (column of Qo) has to be applied to this net base so as to get the waste

Waste % of GTAP production (QO)	**Qo**	**H&S**	**Total**
pdr	6%	8%	14%
wht	6%	8%	14%
gro	6%	8%	14%
v_f	20%	10%	30%
osd	18%	6%	24%
c_b	6%	10%	16%
ocr	20%	10%	30%
ctl	7%	0%	7%
oap	7%	0%	7%
fsh	7%	5%	12%
rmk	4%	6%	10%

So, if the original level of production in GTAP data was to be 100 for all sectors, then waste in production, handling and storage are as shown in the 'Total' column.
We incorporate these numbers (i.e. the numbers in the total column) as the total factor productivity shocks in these agricultural sectors of NAF countries over 2012-2020.
This implies that, given the inputs into production, outputs of these sectors may be increased, or, given outputs, the use of inputs into the production of these sectors may be reduced, implying a rise in productivity by the shown percentages.
The model determines the optimal input-output mix, whereby losses on both input and output side will be reduced. This is over and above technological change in the baseline.